

# 3 Survey Equipment

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## 3.1 Introduction

Procurement and maintenance of surveying equipment, tools and supplies are important components of the Caltrans survey effort. Proper use, care, storage, transportation and adjustment of equipment are major factors in the successful completion of a survey.

This Chapter provides policy, procedure and general information on procurement, control and maintenance of survey equipment, tools and supplies.

## 3.2 Policy Concerning Personal Use of State Property

Any State employee who misuses State equipment or property is subject to adverse action. Misuse includes taking State equipment or property without authorization, damaging or losing it through lack of care, or using it for personal business.

## 3.3 Procurement of Equipment and Supplies

### 3.3-1 Sources of Supply

The following prioritized sources should be considered for supplies. The Division of Procurement and Contracts (DPAC) can help you determine which source is most appropriate.

**Local Inventory:** Always check supplies on hand before placing orders.

**District Warehouse:** Review the District Warehouse (or Stockroom) catalogs for items needed.

**Surplus Elsewhere in the District (or in another District):** A reasonable effort must be made to utilize excess stock within the District/Region before purchasing additional items.

**DPAC Warehouse:** The DPAC Warehouse provides supplies for the daily operating needs of the Department and stocks a wide variety of items in its warehouse in Sacramento. The DPAC Warehouse stocks some common surveying equipment and supplies such as: leveling rods, steel tapes, paint, flagging, stakes, nails, shiners, etc. It also stocks Caltrans manuals, publications and forms. Districts have direct access to the DPAC Warehouse through the Caltrans intranet. Check with DPAC for direct access questions. <http://admin.dot.ca.gov/pc/manuals.shtml>

**Department of General Services (DGS) – Material Services:** Materials not available from the DPAC Warehouse must be ordered from this source, if available. Examples

of the DGS Material Services Warehouse inventory are: State forms, janitorial products and publications.

**Prison Industry Authority (PIA):** Some items produced by PIA include orange coveralls, shirts, vests, other apparel items, work gloves, safety glasses and office furniture. Many PIA items are stocked in District and DPAC warehouses. PIA publishes a product catalogue. Prior to commercial procurement of items similar to those produced by PIA, a written waiver from PIA must be obtained.

### 3.3-2 Purchasing through State Contracts

**State Contracts:** Statewide contracts are awarded by competitive bid for certain volume commodities. Except in emergency situations, purchases of contract commodities cannot be made from outside the contract process. Refer to the DGS Procurement web site for details and guidelines: <http://www.pd.dgs.ca.gov/default.htm>

**California Multiple Award Schedules (CMAS), Master Agreements, State Price Schedules, or California State Computer Stores:** Some commodities can be purchased from suppliers who have negotiated agreements with the Department of General Services (DGS) to supply products at a guaranteed price. These programs are optional, but purchasing equipment up to a specific amount through CMAS or the State Computer Store can be done without using the DGS formal bid process. Contact DPAC for advice on using these programs. Refer to the CMAS web site for details and guidelines: <http://www.pd.dgs.ca.gov/Buy/default.htm>

**Outside Vendors:** Materials not available from the above-named sources can be purchased using Purchase Authorization Purchase Requests (PAPO) or CAL-Card VISA. DGS has delegated a general purchase authority up to specific amounts to the Department. Purchases over the specific limit require a formal DGS bid process. For purchases over the limit, consult with DPAC and consider using CMAS or the State Computer Store. Suppliers should refer to the DGS eProcurement web site for information, details and guidelines: <http://www.eprocure.dgs.ca.gov/default.htm>

### 3.3-3 Caltrans CAL-Card Small Purchase Program

Materials, supplies and services obtained from outside vendors may be purchased using the Caltrans CAL-Card Small Purchase Program, because it expedites payment and reduces paperwork. There is a purchase limit for the CAL-Card purchases and for service orders. Specific limits exist for service orders per year for any one vendor. Cards are issued to individuals, who are responsible for the use of the card. For applications for cards and copies of the “Caltrans CAL-Card Handbook,” contact DPAC or Refer to the DPAC CAL-Card web site for details and guidelines: <http://www.pd.dgs.ca.gov/calcard/default.htm>

## 3.4 Equipment Control Following Acquisition

The *State Administrative Manual (SAM)* governs control of State equipment. For information on property control, refer to the *SAM* (<http://sam.dgs.ca.gov/TOC/default.htm>), the *Property Control Manual (PCM)* (<http://admin.dot.ca.gov/pc/doc/pcm.pdf>), or contact your District Property Controller.

### 3.4-1 Classes of Property

Equipment, materials, and supplies are categorized as expendable or non-expendable. “Expendable” is defined as material or equipment normally consumed while in service. Examples of expendable equipment are tools such as shovels. “Non-expendable” material or equipment is not consumed in service and is expected to have a life expectancy of one or more years. Some examples of non-expendable equipment are survey instruments, chain saws, and computers.

Equipment with a value exceeding \$500, or any sensitive equipment, is assigned a Caltrans Property ID number by the Department’s Property Control Unit. The Headquarters Office of Land Surveys (OLS) affixes a DHQ Property ID number tag to the equipment and uses the ID numbers for inventory purposes and prepares the New Equipment Identification and Accountability Record (Form [ADM-2029](#)).

### 3.4-2 Inventory of Equipment

The *SAM* mandates an inventory of all non-expendable property every three years. To facilitate this triennial inventory, each Surveys Branch should maintain an inventory of all non-expendable equipment and accessories. A person other than the Equipment Coordinator must perform the triennial inventory. The person performing the inventory must sign and date the inventory records. Completion of the triennial inventory is the responsibility of the OLS, the Property Control Unit, and the District/Region Surveys Manager.

The OLS maintains a master inventory of all equipment and accessories acquired and loaned to the District Surveys Offices. Control of this equipment and its accessories within the District is the responsibility of the District/Region Surveys Manager and any change in inventory status must be reported to the OLS.

Although the OLS distributes all non-expendable equipment to the Districts, the actual ownership of any and all equipment purchased by the OLS resides with the OLS.

### 3.4-3 Transfers of Non-Expendable Property

**Equipment Transfer or Loan within the District Surveys Office:** Record keeping for this type of property transfer is very important. If transfers are made without documentation, the person who is assigned the equipment will remain responsible for it until the paperwork is properly submitted. For this reason all equipment transfers or loans should be recorded using an Equipment Transfer or Loan Accountability Record (Form [ADM-2030](#)). Copies of the completed [ADM-2030](#) must be distributed to all involved parties.

**Equipment Transfer or Loan to Other Functions Within District:** Loans of surveying equipment to other District functions may be made at the discretion of the District/Region Surveys Manager. Before any loans are made, the District/Region Surveys Manager should consider employee and public safety as well as overall efficiency of survey operations. Loans of survey equipment must be documented using the [ADM-2030](#) form. Send a copy of the completed Form [ADM-2030](#) to OLS.

**Equipment Transfer or Loan to Other Districts or State Agencies:** The transfer or loan of non-expendable property owned by the OLS between Districts, or between a District and another state agency, requires OLS approval. All transfers must be documented by completing a Form [ADM-2030](#). Send a copy of the completed Form [ADM-2030](#) to the OLS.

### 3.4-4 Disposal of Outdated Equipment

Equipment no longer suitable for use by the Department, because it is obsolete, damaged, deteriorated, or otherwise beyond its useful service life is surveyed (disposed of) by DGS sale, trade-in, donation to another State-funded public entity, or recycling. The OLS coordinates proposed survey (disposal) of surplus non-expendable equipment with the District/Region Surveys Manager. The District/Region Surveys Manager completes Form [ADM-2030](#), and returns the equipment to the OLS. The OLS completes the Request for Property Survey form ([ADM-0395](#)), and in cases of equipment transfer to another State-funded public entity, Transfer of Location of Equipment form ([STD-158](#)).

### 3.4-5 Individual Responsibility

Each employee has a responsibility to “reasonably” care for State equipment. In the event that equipment is lost, damaged, or stolen, and an employee is determined to be “negligent” in that loss, as defined below, the Property Survey Board may recommend that the employee be required to reimburse the Department for the value of the equipment, or a portion thereof, or face disciplinary action. (For Property Survey Board information see: <http://admin.dot.ca.gov/pc/doc/pcm.pdf>)

Black’s Law Dictionary, 8<sup>th</sup> Ed., defines “negligence” as: “The failure to exercise the standard of care that a reasonably prudent person would have exercised in a similar situation.”

### 3.4-6 Lost, Stolen, or Damaged Survey Equipment

Whenever State-owned equipment is lost, stolen, vandalized or damaged, the employee assigned the equipment must immediately follow these procedures for reporting the loss:

- In the case of stolen equipment,, immediately contact the California Highway Patrol and/or the local law enforcement agency with jurisdiction in the area where the loss occurred.
- In the case of accidental damage, law enforcement notification is not required.
- Notify the first-line supervisor and the District Survey Equipment Coordinator.
- If the lost, stolen, or damaged equipment has a DHQ property ID tag, notify the OLS within 24 hours.
- Complete a Report of Lost, Stolen, or Damaged State-Owned Property (Form [ADM-0396](#)).

If Form [ADM-0396](#) is not immediately available, record the:

- Description of the equipment (make, model, serial number, property ID number, etc.) including, if known, original cost or replacement cost with supplementary costs such as shipping and installation.
- Circumstances of the loss, damage, or crime including the date and time.
- Name of employee reporting the loss.
- Highway Patrol or local law enforcement report number.

The employee should submit the report (or equivalent information) to the employee's first-line supervisor. The first-line supervisor will review, sign and add the following information to the report:

- Acceptability of the report.
- Precautions taken to prevent the loss.
- The degree of culpability of the employee and whether negligence was involved.

The final report ([ADM-0396](#)) is then sent to the District/Region Surveys Manager for review and signature before submission to the Property Control Unit. If the equipment involved was originally acquired by the OLS, a copy of the report shall be forwarded to the OLS.

## 3.5 Surveying Instruments

Caltrans survey crews are provided state-of-the-art surveying instruments. Following are typical survey instruments used by Caltrans survey crews:

- Data Collectors/Survey System Controllers, software and accessories.
- Total Station Survey System with accessories.
- Global Navigation Satellite System (GNSS) receivers with real-time data links, and accessories.
- Leveling Systems (automatic optical pendulum and digital bar code reading) and accessories.
- Terrestrial Laser Scanning Systems and accessories.

These surveying instruments are the primary tools available for Caltrans Surveys staff to perform their work. This equipment represents a significant capital investment for the Department. Great care must be taken to ensure that each instrument provides many years of service. As eloquently stated in the 1898 Queen and Company *Manual of Engineers and Surveyors Instruments*:

“Carelessness in exposing the instrument to the curiosity of cattle, or to other unnecessary risk, and in general, an uncouthness of usage, indicate such lack of respect for skilled and conscientious workmanship as to be quite unpardonable.”

Protect surveying instruments and survey equipment from people, animals, equipment, rain, sand, dust, wind, traffic, and other hazards.



### **3.5-1 General**

#### **Survey Instrument Operators Manuals**

Each instrument is furnished with an operator's manual, which may be in digital format. A copy of the manual should be filed in the Surveys office. The manual contains a description of the instrument, specifications, and basic operating instructions along with recommended servicing and adjusting intervals and methods. The operator's manual should be kept with the instrument at all times, and thoroughly studied prior to use of the instrument, particularly when prescribed field checks and adjustments are to be made. Notes collected during adjustment procedures should be forwarded to the District Survey Equipment Coordinator and included in field notes that will be permanently archived. (See Chapter 14, "Survey Records")

#### **Transport and Storage of Survey Instruments**

For transport of an instrument by road or air, use shockproof casing or packing materials to protect the instrument from excessive vibration. If at all possible, retain and reuse the original manufacturer's packaging system. Store instruments in a position consistent with the design of its carrying case. Never transport instruments in the open bed of a truck.

#### **Electrical Power Sources, Use and Maintenance**

A DC power source is required to power electronic instruments and data collection units. Batteries and chargers are supplied with all instruments. For some instruments, a source of 12v DC power may be used. A clip-on power cable may be provided for use with an automotive battery. Such cables must have fused protection against reverse polarity. Transport batteries in a suitable location. Do not transport batteries with loose objects that could possibly contact the battery terminals.

There are various types and models of batteries in use, including NiCd, NiMH, and lithium ion (Li-ion). Select the proper charger provided by the instrument manufacturer or an approved battery charger, based on the voltage and amp-hour rating of the battery. Do not interchange battery chargers. Follow the manufacturers recommended procedures for maintaining best operating parameters.

Use care when connecting or disconnecting power or data cables to or from a survey instrument, GNSS receiver, or survey data collector. To connect the cable, carefully align the index marks on the connector with those on the receptacle. To disconnect the cable, grasp the connector, not the cable. Do not let the cable end fall to the ground! Damage to cables and connectors may be considered negligence.



### **Routine Maintenance and Care of Survey Instruments**

Before using an instrument visually inspect it for damage. Check all exposed machined surfaces including the polished faces of lenses. Check instrument motions for smooth operation.

Clean the instrument exterior frequently in accordance with manufacturer's recommended procedures. Accumulation of dirt and dust can mar machined or polished surfaces and cause friction and uneven motion in the horizontal and vertical movements. Remove dust with a camel's-hair brush and clean soiled non-optical parts with a soft cloth or with a clean chamois. Clean external lens surfaces with a fine lens brush and if necessary use lens tissue. Do not use silicone treated tissue that can damage coated optics; do not use any liquids other than pure alcohol. Take care not to scratch lenses or their coating. Never touch optical glass with your fingers. Do not loosen or attempt to clean the internal surface of any lens.

If an instrument has become wet unpack it at the end of the day. After wiping dry with a soft towel or cloth leave the instrument, and any of its accessories in a secure location outside of the case to dry. Also leave the case open to dry. If the foam inserts for the case are wet remove them for drying. Do not replace the instrument in the case until completely dry.

### **Service and Repair of Survey Instruments**

Periodic servicing, repair or complex adjustments shall be accomplished by authorized service facilities. Service contracts for maintenance and repair of survey instruments and accessories are negotiated through a competitive bid process and administered by the OLS. All service, maintenance, and repair of survey instruments and accessories must be approved by the OLS. Instruments covered by a service and repair contract shall not be serviced by any other means. The following Caltrans' survey instruments are generally covered by State-administered service contracts:

- Data Collectors/Survey System Controllers and accessories
- Total stations and accessories
- GNSS receivers and accessories
- Digital and optical levels and accessories
- Terrestrial Laser Scanner systems and accessories

**Maintenance Schedules & Record Keeping for Instruments:**

Refer to each instrument operator's manual to determine if the manufacturer suggests scheduled service intervals. Total stations should be serviced approximately once every eighteen months. All instruments (or accessories) should be serviced or repaired when:

- The instrument or accessory is inoperative.
- The instrument or accessory is damaged.
- The instrument or accessory does not maintain adjustment(s).
- Mechanical adjustments are stiff or binding.
- Optics are fogged or cloudy.

Each District Survey Equipment Coordinator, in conjunction with the District's Party Chiefs, should maintain records detailing the frequency of service for each survey instrument.

**Use of State-Administered Service Contracts:**

To service or repair an instrument complete a "Survey Equipment Work Order" form (Form [DTFD-GEO-1](#)). Include the instrument and accessories serial numbers and property ID numbers on the form. Provide a description of problem(s) encountered with the instrument and/or accessories and include specific instructions for requested repair services. Also include the requester's phone number. Submit the completed [DTFD-GEO-1](#) to the OLS to obtain a work order number for the service or repair. Distribute copies of the Work Order Form as indicated on the form. A shipping address for the designated service facility will be furnished upon request.

Note: Ship instruments in their carry cases and in the original manufacturers' padded shipping box. If original padded shipping box is unavailable, pack instruments in a sturdy shipping box with adequate cushioning material between their carry case and shipping box. Do not include non-essential accessories for service (adjustment pins, batteries, dust covers, etc.).

**Service/Repair Limits: Service/Repair Cost vs. Remaining Value:**

All OLS-administered service contracts specify that written cost estimates are required.

Generally instruments should be retired when estimated service or repair costs exceed the estimated value after service or repair. The determination of when to retire, rather than service an instrument, shall be made by the OLS in cooperation with the District Survey Equipment Coordinator based on the following factors:

- Cost of servicing.
- Obsolescence of instrument.
- Past service records.
- Availability of parts.
- Availability and cost of new instruments.
- General condition of instrument.

**Service/Repair of Other Survey Equipment:**

Before requesting service/repair of any survey equipment:

- Check manufacturers' warranties.
- Be sure that service does not cost more than replacement.

Service for survey equipment not covered by state-administered service contracts may be provided by:

- Manufacturers' warranties.
- Department-wide service contracts.
- Individual service contracts negotiated with a manufacturer or dealer for specific instruments.
- Use of the CAL-CARD credit card for service on an as-needed basis.

**3.5-2 Data Collector Systems**

Current surveying equipment technology is centered on collecting data and using data in conjunction with various survey instruments and systems. The data collection software can perform coordinate geometry computations and other calculations. Measured values captured by the total station, GNSS receiver, or digital level can be displayed numerically and/or graphically and recorded in the data collector and later downloaded to a computer. Stakeout computations are also generated in the data collector and sent to the total station or GNSS receiver. Stakeout information can be numerically and/or graphically displayed.

Data Collector Systems include:

- Hardware, either on-board an instrument or an external device
- Data Collection software
- A means of communication between the various survey instruments or equipment and the device.
- Accessories (such as batteries and chargers, prism/rover pole bracket, and other miscellaneous accessories)

It is policy that all data collectors be password protected. Contact the OLS if assistance is needed setting up the password for the data collectors. Using data collectors without proper password protection will be considered negligence.

### **3.5-3            Total Stations**

#### **Total Station**

The typical Caltrans total station is capable of precisely measuring horizontal angles, vertical angles, and slope distances. The instrument may be provided with onboard software and/or the capability to connect to an external data collector. Total station accessories include prisms, tripods, tribrachs, batteries and chargers, prism poles, various cables, and other miscellaneous items.

#### **Field Operations**

Precautions to take when operating a total station include:

- Do not leave instruments unprotected or unattended in unsecured areas.
- Do not carry tripod-mounted instruments over the shoulder.
- Remove instruments from the tripod when changing set-up locations.
- Calibrate instruments daily per manufacturer's recommended procedures.
- Ensure the instrument prism offset value is set correctly for the prism(s) in use.
- Ensure that the appropriate version of the instrument's firmware is installed.
- Never point the telescope directly at the sun. The sun's rays may damage the electronic distance measuring (EDM) circuitry.
- If possible shade the instrument from direct sunlight as excess heat may reduce the range of the sender diodes in the EDM circuitry.

- To maintain maximum signal return at longer ranges shade prisms from direct sunlight.
- Avoid multiple, unrelated prisms in the same field of view; this can cause blunders in distance observations.
- Most total stations are equipped to detect and correct various instrumental errors. If such errors exceed program limits, error codes will indicate the error. Consult the operator's manual for exact procedures and error code definitions.
- When possible select instrument set-up locations to minimize the exposure of the instrument operator, other members of the crew, and the instrument to danger. Select stable ground or footing for the tripod feet. Do not set an instrument directly in front of or behind a vehicle or piece of construction equipment that may suddenly move.
- In the event that the instrument or any personnel are required to be in an area subject to traffic, protection procedures outlined in Chapter 2, "Safety," must be followed.

### **Prisms**

Several types of prisms are available within Caltrans inventory, including standard prisms, mini prisms, 360° prisms, and active prisms. Each prism will likely have a different prism offset value. To obtain accurate survey results it is essential to set the instrument to the correct prism offset value for the prism(s) in use. If using a total station with an external data collector, prism constants should only be set in the total station or in the data collector. Never set the prism offset in both devices.

Guidelines to properly maintain prisms include:

- Transport and store prisms separately in padded compartments, padded containers, or softcases to prevent damage.
- Do not lay prisms where they might be damaged, for example in the bed of a truck.
- All prisms should be removed from prism poles before storage.
- Clean glass surfaces regularly using water and a soft towel or specially treated, silicon free lens cleaning tissue.

### 3.5-4 Global Navigation Satellite System (GNSS) Equipment

Field components of GNSS survey systems include:

- Receivers
- Data collection system
- Antennas
- Data link system (for real-time positioning)
- Accessories (such as cables, tripods, tribrachs, batteries and chargers, rover poles, and other miscellaneous accessories)

#### GNSS Receivers

A typical survey-grade GNSS receiver is encased in a durable housing that is lightweight and weatherproof. GNSS receivers require line-of-sight reception of the satellite signals and perform best when the antenna has an unobstructed view of the sky. Ensure that the appropriate version of the receiver's firmware has been installed. Radio frequency energy from nearby radio, television, or radar transmitters may overpower GNSS receiver circuits. Attempt to stay at least a quarter of a mile away from such electromagnetic field sources. Low power handheld radio operations may also interfere with operation of a GNSS unit.

#### Antennas and Cabling

Two types of external antennas are used with typical GNSS units. The geodetic antenna has a groundplane and is used for static GNSS surveys. It is mounted on a tribrach/tripod or a fixed height pole with a stabilizing tripod. The antenna is precisely centered and leveled over a survey mark or monument for high accuracy GNSS measurements.

The rover antenna, used for kinematic and real-time kinematic GNSS surveys, is mounted on a fixed-height rover pole and may be supported by a bipod. Some GNSS systems are combined with the receiver, antenna, and data-link in a single housing. The units purchased by Caltrans have an internal ground plane and are acceptable for geodetic surveys.

Both types of external antennas may be connected to the receiver by a detachable cable. Care must be taken not to kink or pinch the cable. The antennas are completely sealed and weather resistant, and require no calibration or adjustment. Use the appropriate antenna for the receiver and document the type in the field notes.

Transport and store external antennas only in provided cases.

### 3.5-5            **Leveling Instruments and Rods**

Caltrans survey crews are generally equipped with an optical pendulum level or a digital level and direct elevation, 2 piece differential, 25-foot fiberglass, and/or barcode rods.

#### **Optical Pendulum Level**

Pendulum levels are fast, accurate, and easy to maintain. Proper care and adjustment is required to provide continuous service and to maintain precision in measurement. Never disassemble an instrument in the field. Only make those adjustments outlined in the operator's manual.

#### **Care of a Pendulum Level:**

- To prevent compensator damage, do not spin, bounce, or hit pendulum levels.
- Protect the level from dust. Dust or foreign matter inside the scope can cause the compensator damping device to hang up.

**Circular Bubble Test and Adjustment:** Frequently check adjustment of the “bullseye” bubble. Adjust the bubble to the center of the “bullseye”. Make certain the bubble is adjusted along the line of sight and 90° to the line of sight as well. Proper adjustment reduces the possibility of compensator hang-up. Adjustment will be easier if done in the shade, where the temperature is constant.

The Horizontal Cross-Hair Test and Adjustment (Two-Peg Test) should be performed at least once every 90 days; when discrepancies show up in the leveling work; or before three-wire level surveys. To perform the Two-Peg Test:

- Select two benchmarks “A” and “B” approximately 200 feet apart.
- Set up the level midway between the two points “A” and “B”. Record the rod readings of each point determining the difference in elevation.
- Move the level 20 feet beyond either benchmark and record the rod reading of both points again. Determine the difference in elevation again.
- If the difference in elevation measured at each set-up is the same, the level is in adjustment. If not, the horizontal cross-hair should be adjusted as detailed in the operator's manual.
- After the adjustment, repeat the Two-Peg Test again to check the adjustment.

To check for proper compensator function lightly tap the telescope with a pencil or operate the fine movement screw to and fro while watching the cross hairs move and return to their original position. If the compensator is slow to respond or malfunctioning contact the District Survey Equipment Coordinator for service or repair. There are no mechanical field adjustments that can be made on the compensator.



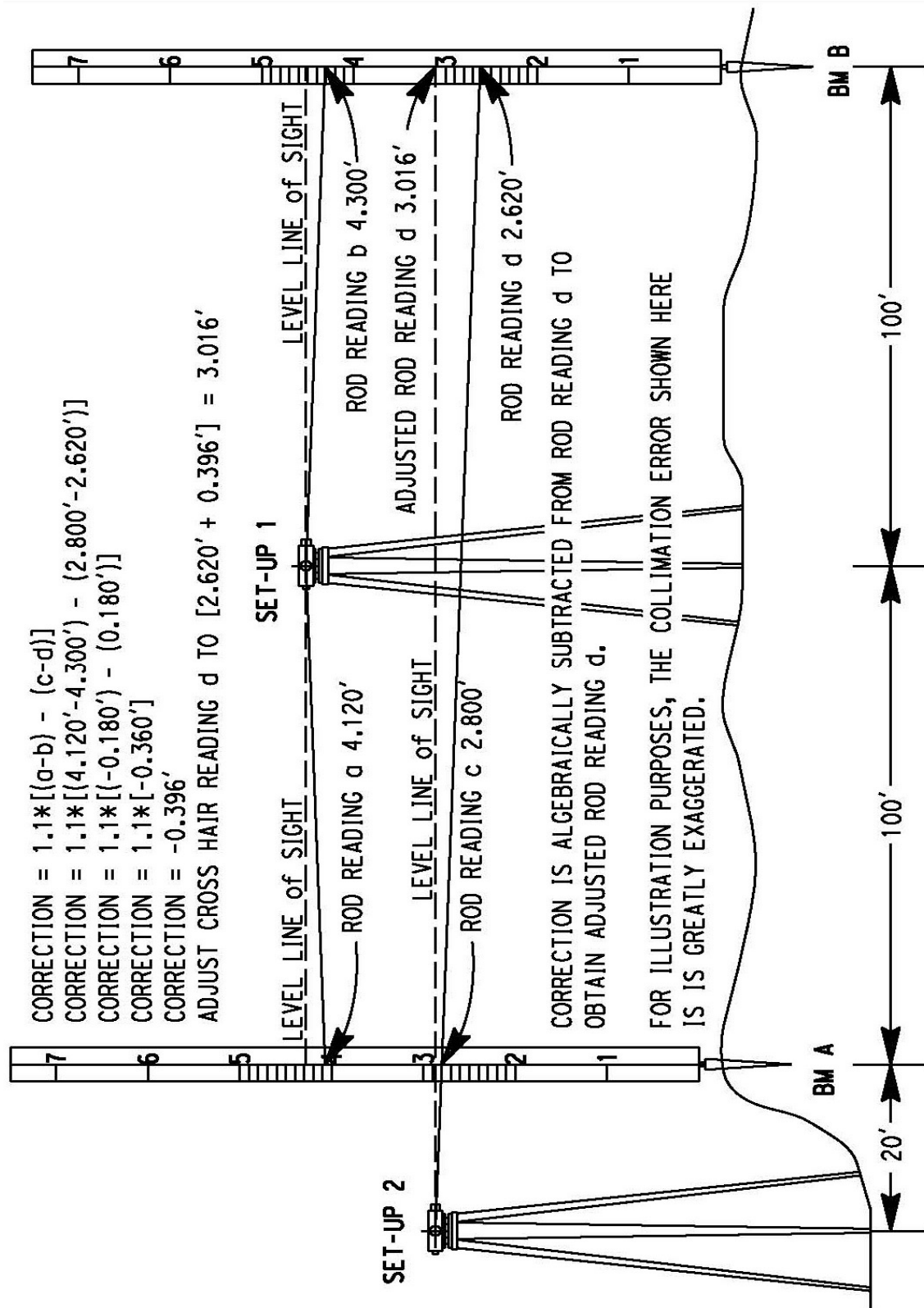


Figure 3-1 Two-Peg Test and Adjustment

## Digital Level

Digital levels operate by comparing the observed digital image of a bar-code leveling rod with a map of the barcode stored in the level's memory. These instruments are also equipped with a conventional pendulum-type compensator and may be used as an optical level. The instrument records all leveling observations.

A digital level system should include:

- Digital level with data recorder module or cable connection to a data collector
- Data reader and/or appropriate interface/cables
- Barcode leveling rods
- Fixed-leg tripod for high precision leveling

**Field Operations:** At the beginning and end of each day's operation check the instrument for collimation error, recording the test results into the survey notes. When using digital leveling instruments, the absolute collimation error will be recorded along with the leveling data. If an error in excess of 0.005 foot within a 200 foot sight distance is detected, the level should be readjusted. If the instrument is severely jolted or bumped, or suspected as such, it should be immediately checked.

Manufacturers' specifications state that for high precision leveling the digital leveling instrument should not be exposed to direct sunlight and recommend use of an umbrella in bright sunlight.

The test and adjustment procedure for an electronic digital level is similar to the procedure for a conventional optical level. Refer to the manufacturer's instrument operator manual or user guide for test and adjustment procedures.

**Data Collection, Storage, and Transfer:** Raw data generated by a digital level is stored internally or in a data collector and processed into field book format. Software will perform simple or least-squares adjustment of the data.

## Leveling Rods

Conventional and barcode leveling rods should be maintained and checked as any other precision equipment. Accurate leveling depends as much on the condition of the rods as on the condition of the level. Reserve an older rod for rough work such as measuring inverts, mud levels, water depths, etc.

**Routine Maintenance and Care:****Maintenance procedures common to all types of rods are:**

- Periodically check condition of rod for proper function and operation.
- Clean graduated faces with a damp cloth and wipe dry.
- Keep the base plate clean.
- Periodically lubricate hardware and slip joints with an oil-free silicon spray.
- Clean sand and grit from slip joints.
- Periodically check all screws and hardware for proper function.

**Transport and Storage:**

- Store rods in protective sleeves or cases, in a dry location, either vertically (not leaning), or horizontally. When stored horizontally, fully support the rod or provide at least three-point support.
- If possible leave a wet rod uncovered and extended until it is thoroughly dry.

**Field Operations:**

- Touch graduated faces only when necessary and avoid laying the rod where the graduated face will come into contact with other tools, objects, or materials that could mar the face.
- Do not abuse a rod by throwing, dropping, dragging, or placing it where it might fall. (A leaning rod is a falling rod!)
- Do not lay a rod in sand, dust, or loose granular material.
- Lower rod sections as the rod is being collapsed. Do not let the sections fall or drop.

At frequent intervals, check direct reading rod components for wear. If the tape guides begin to snag or bind the tape have the rod repaired.

Spring loaded buttons on fiberglass leveling rods protrude through precisely matching holes in each section to lock the sections in place while extended. Dowels through the bottom of each section keep the section above from falling inside the lower section when the rod is collapsed. Allowing the sections to free-fall when collapsing the rod will loosen or damage the dowels, causing the sections to jam and may shatter the fiberglass around the dowels.

**Observe the following precautions:**

- When a locking button joint goes bad remove the fiberglass rod from service.
- Although fiberglass is non-conductive dust and/or moisture on the surface of a rod can allow electricity to be conducted on the surface of the rod. Use caution when working around power lines.

Invar leveling rods are precisely calibrated with the digital level; therefore extra care is required to maintain this calibration. Observe the following precautions:

- Always use a turning pin or turning plate (“trivet” or “turtle”) for turning points.
- Never set the bottom plate of an invar rod on the ground.
- Never lay an invar rod on the ground.
- Store fully supported and stopped in a waterproof case.
- Do not use invar rods in rain or dust.
- Carry parallel with the ground in alternate “face-up” and “face-down” positions to equalize weight stresses.
- If foreign matter has fouled a rod carefully remove the material and clean.
- The rod tape must slide freely in the recessed guides as the staff expands or contracts.

Contact the OLS to arrange for invar rod and digital level calibration.

### **3.5-6 Stationary Terrestrial Laser Scanning Systems (LiDAR)**

The laser scanner is tripod mounted and typically controlled by a laptop computer. For detailed operational information refer to Chapter 7.

Components of scanner systems include:

- Laser scanner
- Laptop computer for scanner control and data collection
- Various cables
- Accessories (such as tripods, batteries and chargers, targets, target poles, and other miscellaneous accessories)
- Workstation computer for data manipulation and processing
- Portable generator for powering laptop and scanner when scanning sessions exceed the capabilities of available battery power

### **Laser Scanner Field Operations**

- Never look directly at terrestrial laser scanner measurement beams. Most scanners use eye safe lasers but they can still cause eye damage at close range. Also the beam should not be looked at through a telescope or binoculars, which can concentrate the laser energy. Caltrans personnel should guard against curious members of the public looking into the beams.
- Scanners go through a calibration process at startup. Strong wind or vibration can interfere with this process. Select set-up locations with low vibration and use during low wind conditions.
- When possible select laser scanner set-up locations to minimize the exposure of the operator, members of the crew, and the laser scanner to danger. Select stable ground or footing for the tripod feet. Do not set a laser scanner directly in front of or behind a vehicle or piece of construction equipment that may suddenly move.
- In the event that the laser scanner or any personnel are required to be in an area subject to traffic follow protection procedures outlined in Chapter 2, Safety.
- Pavement conditions can greatly affect the distance the scanner can measure. Newer black pavement will return less energy to the scanner than older, graying asphalt and limit the distance measured. A sample scan on typical pavement conditions should be done before setting out scan control on a long project.
- Snow, rain, blowing dust, smoke, and fog can cause problems when scanning. Operate the scanner in clear conditions for best results. The scanner is not waterproof - do not use in the rain.

Precautions to take when operating a laser scanner include:

- Do not leave the scanner unprotected or unattended in unsecured areas.
- Clean the scan windows using the material provided to prevent scratching the glass.
- Calibrate daily per manufacturer's recommended procedures.
- Check the tribrach bubble level and centering error on a regular basis.
- Scanners are generally heavier than total stations. Use a tripod with double clamping mechanisms for added safety.
- Remove the scanner from the tripod when changing set-up locations
- Use sandbags on the tripod or bipod legs to prevent the scanner or targets from being blown over by vehicle induced wind gusts or in windy conditions.
- Check the tripod for tightness and adjust as needed.

- Scanners can be operated at night, but not in conditions with particles or precipitation in the air. Plan project and set-up locations for safety.
- Do not step on the cables or drop cable ends onto the ground. This can damage the cables and connectors.

## **Targets**

Several types of targets are available including standard tribrach targets, pole mounted double targets, and spherical targets.

Guidelines to properly maintain targets include:

- Transport and store targets separately in padded compartments, padded containers, or softcases to prevent damage.
- Do not lay targets where they might be damaged, for example in the bed of a truck.
- All targets should be removed from target poles before storage.
- Clean target surfaces as needed, using water and a soft towel.

## **3.5-7 Survey Instrument Accessories**

### **Tripods**

Tripods support and provide a fixed base for all types of surveying instruments. The typical tripod used for Caltrans Surveys has a 5/8-in. x 11 thread fastener to secure an instrument, antenna, or accessory to the tripod head. The head provides a lateral adjustment range for the instrument or tribrach of approximately 1 inch. The tripods are of a wide-frame design and have extendible legs. For precise leveling use a fixed leg tripod.

A secure and stable tripod is required for the support of precision instruments. There should be no slack between the various components of a tripod. Loose joints or fittings will cause instability.

Some guidelines to properly maintain tripods are:

- Maintain proper torque on all metal fittings. Over-tightening is the cause of crushed components and stripped threads.
- Tighten leg hinges just enough to support the fully extended legs when a tripod is lifted clear of the ground.
- Keep the metal tripod shoes tight and free of dirt and debris.

- Keep wooden parts of tripods well painted or varnished to reduce swelling and shrinking due to moisture content of the wood.
- Always replace top caps when tripod is not in use to protect the mounting surface and head from damage.
- Use care when placing or removing tripods from the survey vehicle as significant damage can occur. Ensure that carry compartments are designed and constructed to isolate tripods from each other and from other equipment.

### **Tribrachs**

Tribrachs are the detachable base for most survey instruments and many accessories. They are typically equipped with an optical or laser plummet and spherical “bullseye” level.

Some guidelines to properly maintain tribrachs are:

- Transport tribrachs in separate compartments or containers to prevent damage to the base surfaces, spherical level and optical plummet.
- Do not over-tighten the tripod fastener screw.
- Do not over rotate the leveling screws.
- Do not over rotate the optical plummet focusing knob.
- Clean leveling screws regularly.
- When tribrachs are not in use set leveling screws at mid-range, usually marked by a horizontal line.
- Use care whenever using range poles mounted on a tribrach to vertically extend a sight, antenna, or prism. Extensions place considerable stress on the leveling plate.
- Check and adjust spherical bullseye level and vertical collimation of plummet routinely.

### **Prism/Rover Poles**

An attached adjustable spherical bullseye level bubble is used to maintain a prism/rover pole in a vertical position. A maladjusted level bubble may cause systematic error when using the pole. Jigs are available for checking and calibrating prism and rover poles.



## **3.6 Computer Systems**

To effectively process the large volume of electronic data produced by Caltrans survey crews, each Surveys office should be equipped with adequate computing, storage, document scanning, and printing equipment.

### **3.6-1 Office Computer Systems**

Each Surveys office employee should have access to a computer workstation with sufficient processing and memory capability to efficiently operate design and survey software.

### **3.6-2 Field Computer Systems**

The OLS provides a laptop computer for each survey party per the Survey Party allocation guidelines. The laptop computer should have processing and memory capability to efficiently operate surveying software. For information on upgrades, service, and repairs contact the OLS. Laptops must have encryption software enabled.

### **3.6-3 Caltrans Policy Regarding Use of State Computer Systems**

Use of Caltrans computer equipment for personal business is subject to adverse action. For more detailed information on this policy see the current Directors' Policies and Deputy Directives concerning computer usage and information technology.

## 3.7 Vehicles

Care and operation of State-owned vehicles are detailed in the vehicle owner or operator manual. Departmental policies covering safe vehicle operation including: use of seat belts and shoulder harnesses; driver license requirements; defensive driver training; misuse of vehicles; and related safe motor vehicle operation practices can be found in Chapter 17 ([http://www.dot.ca.gov/hq/opo/safety/safetymanual/Chap\\_17\\_Jul2007\\_r111008.pdf](http://www.dot.ca.gov/hq/opo/safety/safetymanual/Chap_17_Jul2007_r111008.pdf)) of the *Caltrans Safety Manual*. Additional vehicle and travel policy information can be found in the SAM. Refer to Chapter 18 of the *Caltrans Safety Manual* ([http://www.dot.ca.gov/hq/opo/safety/safetymanual/Chap\\_18-2000.pdf](http://www.dot.ca.gov/hq/opo/safety/safetymanual/Chap_18-2000.pdf)) and the *Operation, Accident and Emergency Service Information* booklet when dealing with operation and emergency service issues. This booklet is in the “Vehicle Accident Reports” envelope in the glove compartment of all State vehicles. All employees who drive State-owned vehicles should familiarize themselves with the contents of this booklet.

The appropriate Hourly Vehicle Log or Mileage Vehicle Log and Daily Pre-Operation Report must be completed each day that a vehicle is used.

Vehicle operation and care are joint responsibilities of all survey field crewmembers. Some of these responsibilities are:

- Comply with departmental policies, State and local laws and regulations regarding the use of State vehicles.
- Use of seat belts by all.
- Use of defensive driving techniques.
- Operate within the physical and mechanical limitations of the vehicle.
- Maintain awareness that the operation of a State vehicle is a highly visible activity to the public and to fellow employees.

Guidelines for safe motor vehicle operation are found in Chapter 17, “Motor Vehicle Safety” of the *Caltrans Safety Manual*.

### 3.7-1 Misuse of Vehicles

Use of a State owned vehicle for personal business is subject to adverse action. For details see Section 17.12, “Misuse of State-owned Motor Vehicles” of the *Caltrans Safety Manual*.

### 3.7-2 Home Storage of State Vehicles

Home storage of Caltrans vehicles is permitted in cases when secure Caltrans storage for vehicles is not available and when it is in the best interest of the State to store vehicles at home so that employees can begin the workday at the job site. Home storage is not allowed to enable employees to commute in State-owned vehicles. A Home Storage Permit (HSP) is required for employees on State business who drive and store a State vehicle at home at least 36 nights in three months or 72 nights in one year. The HSP application process is available only through the automated, online system. HSPs are valid only during one given fiscal year, and must be reviewed annually. Review the HSP website, 2009 HSP guidelines, and DD-28-R2 for more information:

<http://cap3.dot.ca.gov/equip/hsp/HSPintro.htm>

<http://cap3.dot.ca.gov/equip/hsp/Documents/HSPGuidelines.pdf>

<http://onramp.dot.ca.gov/hq/equipment/fleet/HomeStorage/DD28R2.pdf>

### 3.7-3 Security of Vehicles

The operator or user of a State vehicle is responsible for the security of the vehicle and its contents when parking or storing it. The following security precautions shall be followed:

- Remove ignition keys; close and lock all windows, doors, and compartments.
- Store survey instruments and other valuable equipment, such as laptop computers, during times of non-use in a “double-locking” compartment. A “double-locking” compartment is defined as being secured with two separate locking devices, usually a lockable handle and an additional deadbolt or hasp and padlock. Survey instruments and computers shall be removed from the vehicle, and stored in a more secure location if available, outside of working hours.
- Park off the street whenever possible. In residential areas you must park off the street unless specifically authorized to do otherwise.
- Leave vehicle in “low” or “reverse” in manual transmissions, or “park” in automatic transmissions and with the emergency brake firmly set. If parked on a grade, turn the front wheels to roll into the curb or off the road.

### **3.7-4 Off-Road Operations**

Four-wheel-drive vehicles are equipped for use in rough terrain or adverse driving conditions that make travel in two-wheel drive vehicles hazardous or impossible. Not all four-wheel-drive vehicles operate in the same manner. Consult the operator's manual for appropriate operation of a particular make and model of vehicle.

Some guidelines for the proper use of four-wheel-drive vehicles are:

- Do not wait until there is a problem to use four-wheel drive.
- Make certain the transfer case and the front drive hubs are engaged.
- Do not engage the low range without having the hubs in locked positions.
- Keep your speed below 25 mph when in four-wheel drive.
- Do not drive on pavement in four-wheel drive.
- Avoid side-hill operations.
- Secure all equipment before traveling on rough or difficult terrain.

### **3.7-5 Obtaining Fuel, Service, and Parts**

Whenever feasible fuel, service, and parts must be obtained from a State facility or contractor. Make an effort when purchasing fuel, service, and parts from a commercial facility to obtain the lowest possible cost for the state.

Purchases from commercial vendors for State vehicles should be made using the State gas credit card. Before using the State gas credit card, check for acceptance prior to delivery of the product or service. The operator of a State vehicle must assure proper credit card usage.

Consult with the District Equipment Shop or traveling Heavy Equipment Mechanic by telephone or radio before committing the State to emergency repair purchases. Submit written justification along with the receipt or invoice of charges for any emergency purchases.

### 3.7-6 Preventive Maintenance

Preventive maintenance is a regularly scheduled program of checks, inspections and services designed to provide maximum uptime and to prevent unsafe or untimely failures of equipment.

The Division of Equipment (DoE) is responsible for scheduled lubrication, preventative maintenance (PM), and accurately maintaining service records. The DoE will notify equipment users of the next PM due date. It is the responsibility of the user to notify the DoE in advance of any service needs prior to any pre-programmed service dates and mutually arrange access for service. There may be occasions when Surveys personnel will assist in servicing a vehicle. Operators are responsible for detecting and reporting the first signs of faulty equipment. Use the pre-trip/post trip checklist for reporting any signs of problems to supervisors. Do not operate vehicles with faulty equipment or known safety issues.

A PM program shall be followed for each survey vehicle. This program and pertinent procedures are covered in the Equipment Service Center's July 1, 1995 [memo](#) revising the July 13, 1994 Mobile Equipment Preventive Maintenance Guidelines.

[http://onramp.dot.ca.gov/hq/equipment/operations/Handbook/3-Equipment/3.35MobileEquipmentPreventiveMaintenanceProgram\(REVISION\).htm](http://onramp.dot.ca.gov/hq/equipment/operations/Handbook/3-Equipment/3.35MobileEquipmentPreventiveMaintenanceProgram(REVISION).htm)

The PM program includes:

- Daily pre-operation inspection and reporting using the Daily Pre-operation Inspection Booklet (DME - 151).
- Regular preventive maintenance and inspections as required.
- Use of the Permanent Equipment Maintenance Record (PEMR) Book for all vehicles.

### 3.7-7 Roadside Mechanical Repairs and Assistance

All State-owned vehicles are provided with a *Vehicle Emergency Services Directory* listing who and where to call in the event the vehicle becomes disabled. Roadside repairs and assistance are available during normal operating hours from the local equipment shop facility.

Never leave a disabled vehicle where it may block the normal movement of traffic. Always attempt to move the disabled vehicle off the roadway for diagnosis of the problem as well as repairs. If necessary have the vehicle towed to a safe location.

Notification procedures may vary from District to District, but in general, the order of contact should be the Survey Party Chief, Field Survey Supervisor, and then the Equipment Shop Supervisor:

- Report the vehicle information, problem, and location.
- Describe the symptoms of the mechanical breakdown.
- A Caltrans traveling Heavy Equipment Mechanic *may* be able to repair the vehicle.
- If field repairs are not available, arrange for a tow truck using the information on the back of the fleet vehicle fuel card.
- Confirm completion of the PEMR Book for any field vehicle repairs.

### 3.7-8 Using Privately Owned Vehicles for State Business

Use of privately owned vehicles on State business may be permitted if advantageous to the State or if a State vehicle is unavailable. For instructions and rules for the use of privately-owned vehicles for State business see the *Caltrans Travel and Expense Guide*, Chapter 3, “Private Vehicle Use” at [http://www.dot.ca.gov/hq/asc/travel/ch3/7lta\\_trexp.htm#pv](http://www.dot.ca.gov/hq/asc/travel/ch3/7lta_trexp.htm#pv)

Advance authorization is required for use of a privately owned vehicle on State business. Authorization is obtained by filing Form [FA0205A](#), “Authorization To Use Privately-Owned Vehicles on State Business.” This form must be filed annually.

<http://cefs.dot.ca.gov/forms/index.html>

Privately owned motorcycles are not authorized for use on State work.

## 3.8 Radio Communication Systems

Good communication is essential to efficient and safe surveys operations. Surveys employees must utilize the Caltrans radio communications system properly, as the system is operated under a license from the Federal Communications Commission (FCC). Violation of FCC rules could result in loss of frequency privileges.

The primary statewide system consists of more than 10,000 mobile units and some 1300 base stations. (Mobile units include radio-equipped vehicles and portable, hand-held radios). It is classified as a mobile radio system. Base stations are usually located at district offices and the offices of maintenance superintendents and resident engineers. Transmitters and repeater stations are located on mountaintops to obtain greater range.

Survey field crews use the statewide mobile radio system for communication with the District Surveys office, other field crews, and individuals on the same crew. Shorter range hand-held radios are preferred for communication between members of the same survey crew. Due to frequency mismatches some vehicle-mounted mobile radios cannot interact with the hand-held radios.

For more detailed information on the Caltrans radio system, see the [\*Caltrans Radio User's Guide\*](#).

### 3.8-1 Purchase and Service

Caltrans statewide radio equipment is obtained and serviced by the Caltrans [\*Office of Radio Communications\*](#). Contact the District Radio Coordinators to obtain new systems or when existing systems require service.

Short-range hand-held radios may be provided by the OLS. Contact the OLS for service or repairs.

Do not automatically assume that your radio is at fault when you are unable to communicate with a desired station. The other radio, associated control equipment, or repeater station might be defective. Also the operator of the other radio might be temporarily away from the radio, you could be out of range or in a “dead” spot, or the other radio might be turned off.



### **3.8-2 Transport and Storage**

Radios should be kept in their carrying cases at all times. Avoid laying a radio in precarious places where it could be dropped or knocked to the ground. Never pick-up a hand-held radio by its rubber antenna. Do not clip the microphone to the radio antenna.

### **3.8-3 Field Operations**

Precautions to be taken when using radios are:

- All messages should be as short and to-the-point as possible.
- Speak in plain language at a moderate rate, using words with a clear definition, while holding the microphone close to, but not touching, the mouth.
- Pause and listen before you push the transmit button.
- Do not break into ongoing conversations unless your transmission is an emergency.
- Portable radios should never be left laying in direct sunlight for extended periods of time.
- Never transmit near blasting operations without first receiving clearance from the person in charge.
- Trade off hand-held radios or batteries so that one is not used exclusively for transmitting. Lengthy transmissions require considerably greater battery discharge than receiving only.
- Battery life of the receiving hand-held radio may be extended by simply clicking the transmission button to acknowledge receipt of a message.

### **3.8-4 Improving Radio Transmission Quality**

Radios do not always work equally well in all directions. Because of terrain or obstructions radio transmissions may be directional. If you are unable to communicate with a desired station (unit), try the following:

- Turn your radio to face another direction.
- Change location (sometimes only a few yards helps).
- Move to a higher elevation (an overpass can sometimes help).

## Appendix 3A: Survey Party Equipment List

The following is a list of assorted equipment, tools, and materials available to a Caltrans survey crew. Not every item on the list will be assigned to each crew. This list may be modified when performing non-routine surveys or when operating in remote locations.

### Equipment List for Caltrans Survey Crew

#### Quantity .....Description of Item

1 each.	Electronic Total Station instrument including and batteries
1 each	GNSS RTK system including Base to Rover data link and batteries
3 each	Data collection device with cables and batteries
1 each	Digital level and “bar code” rods
1 each	Automatic optical pendulum level
1 each	Laptop PC capable of running approved survey software
1 each	Computer printer (portable, ink jet)
1 each	Cellular telephone
5 each	Tripods
5 each	Tribrachs
1 each	Tribrach level-bubble-adjusting block
1 each	Tribrach optical-plummet-adjusting cylinder
5 each	Single prism assemblies and stems
1 each	360° prism
2 each	Standard extendible prism poles
2 each	15 foot layout/prism poles
3 each	25 foot fiberglass rods with prism adapters
1 set	Matched geodetic leveling rods (Contact OLS for geodetic bar-code rods)
2 each	Direct reading elevation rods
Assortment	Fiber and steel tapes (12-100 feet)
4 each	Plumb bobs
2 each	Barometer and thermometer
1 each	Rola-Tape wheeled measuring device
1 each	Magnetic field pipe (monument) locator
1 each	Battery charging/cycling device
1 per person	Handheld FM two-way radios
1 each.	Programmable handheld radio with appropriate District/Region Surveys and/or Maintenance and Construction frequencies
1 each	Telescoping pole saw
1 each	Camera (Digital or film)
1 each	First aid kit (16 unit)
1 each	Drinking water cooler (5-gallon)

## Equipment List for Caltrans Survey Crew, continued

### Quantity .....Description of Item

14 each	Traffic cones
12 each	Warning flags
2 sets	“Survey Crew Ahead” signs
1 each	Traffic accident surveillance & analysis system (TASAS) listing
1 each	District/Region post mile map
1 each	District/Region list of emergency and medical facilities (phone numbers and locations)
Assortment	Insect repellent
Assortment	Anti-tick release and removal kit
Assortment	Safety glasses (gray, amber and clear)
Assortment	Ear protection devices
Assortment	Gloves (both leather and cloth types)
Assortment	Toxic vegetation barrier cream
Assortment	Wooden stakes
Assortment	Plastic construction staking cards
Assortment	Rebar, 30-inch and 18-inch long, with aluminum caps
Assortment	Galvanized iron pipe, 30-inch and 18-inch long, with plastic plugs
Assortment	Brass caps and brass caps on iron pipes
Assortment	Impact tools for brass cap on rebar, and pipe
Assortment	Hand tools (hammers, gads, wrenches, etc.)
Assortment	Cutting tools (machetes, axes, hatchets, etc.)
Assortment	Ribbon flagging (various colors)
Assortment	Nails (100 d spikes, 16d nails, asphalt pavement nails, concrete nails, etc.)
Assortment	Writing materials (pens, pencils, markers, etc.)
Assortment	Drafting tools (triangles, symbol and arc templates, various scales, etc.)
Assortment	Note forms (grid, survey, etc.)
Assortment	Paint (white, orange, black, green, etc.)
Assortment	Digging tools (shovels, picks, digging bars, etc.)
Assortment	Large clear plastic garbage bags to protect equipment from inclement weather.
2 each	Whisk broom
Assortment	Various size die stamping sets
Assortment	Hard hat liners and gloves for protection from cold
1 copy each	Surveys Manual; Safety Manual; California Manual of Uniform Traffic Control Devices (MUTCD); and Chapter 8, “Protection of Workers” of the Maintenance Manual
1 set	Snow chains
1 set	Jumper cables
1 box	Warning flares
2 each	Staplers (gun type for staking cards and a standard office stationery type)
Assortment	Office and stationery supplies (rubber bands, paper clips, envelopes, etc.)